Recent and Future ID Developments at the ESRF

P. Elleaume,

On behalf of the ID & Vacuum Group

Continuous ID Refurbishment

Segments	Type	Length [m]	Min Gap [mm]	Material
6	In-vacuum Undulators	~ 2	5-6	Sm_2Co_{17}
13	Undulators & 3T Wiggler	~ 1.6	11	NdFeB
38	Undulators	~ 1.6	16	NdFeB
8	Wigglers	~ 1.6	20-25	NdFeB
65	Total			

A number of exotic IDs : Helical, Apple II, Quasiperiodic,….
More details @ : http://www.esrf.fr/machine/groups/insertion_devices/Ids/installed_IDs.html

8 mm Aperture ID chambers

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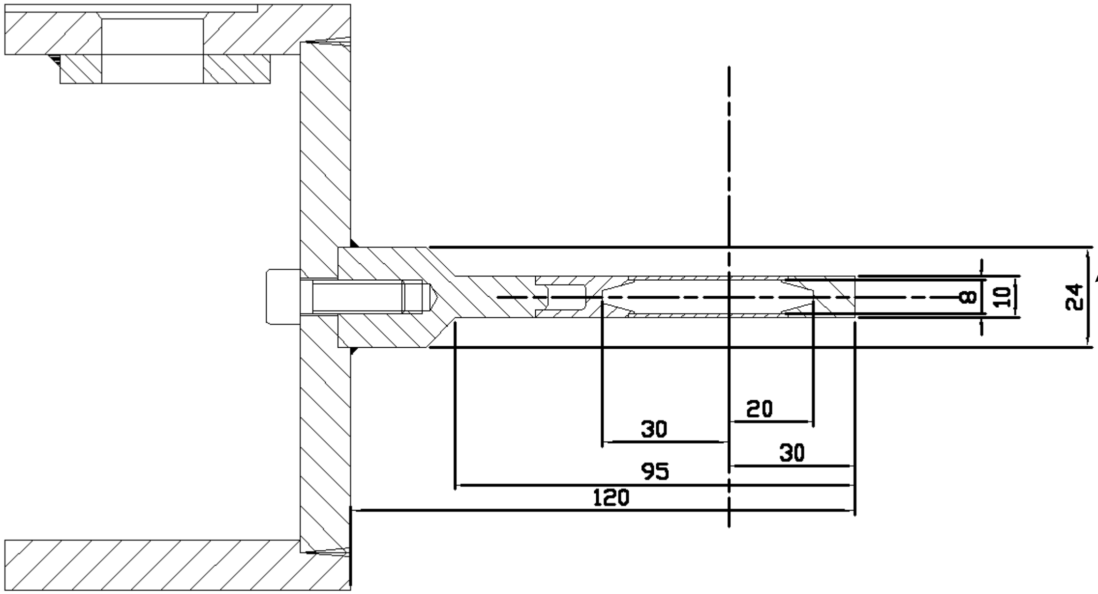
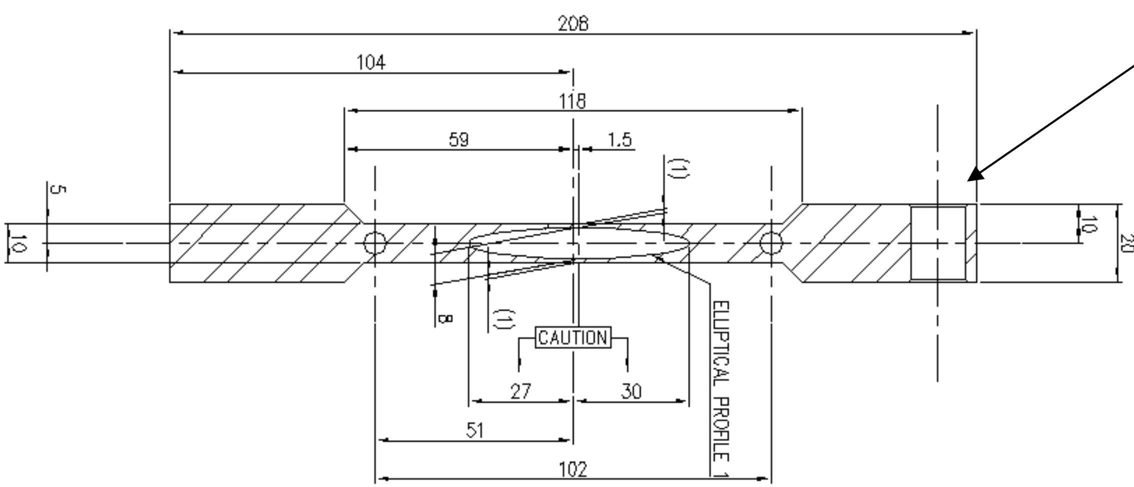


Welded Stainless Steel
Aperture 8 mm, Length 5 m
50 micr. Electro-Depos. Copper
1 micr. NEG Coating
5 installed in Jan 2003



Extruded Stainless Steel
Aperture 8 mm, Length 5 m
1 micr. NEG Coating
1 Installed Jan 2003

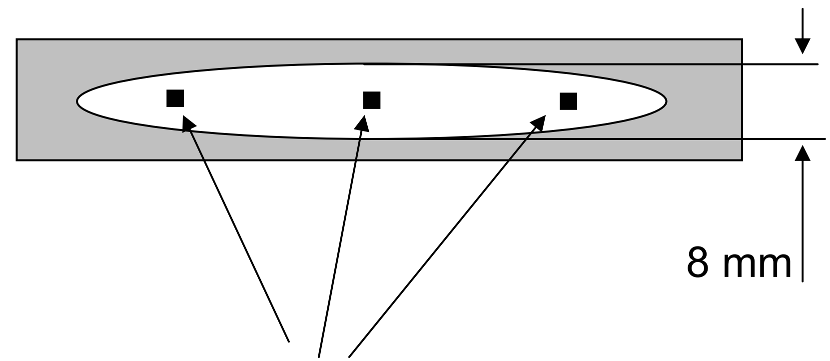
Coating of ID Vacuum Chambers with Non Evaporable Getter (NEG) material

ESRF

- Technology developed at CERN in the Benvenutti Group
- Magnetron type Sputtering of Titanium, Zirconium and Vanadium to a thickness of ~ 1 μm.
- Following installation in the ring, the NEG is activated by baking the vessel at 180° C for ~ 4 hours.
- Results have shown a considerable shortening of the vacuum conditioning time seen by :
  - vacuum gauges
  - electron beam lifetime
  - residual bremsstrahlung measured in the beamline .
- Following the fresh installation of a 8 mm aperture 5 m long NEG coated chamber, the lifetime reached ~ 30 hours within 10 minutes of operation at 200 mA independently of the material of the chamber (stainless steel or aluminium).

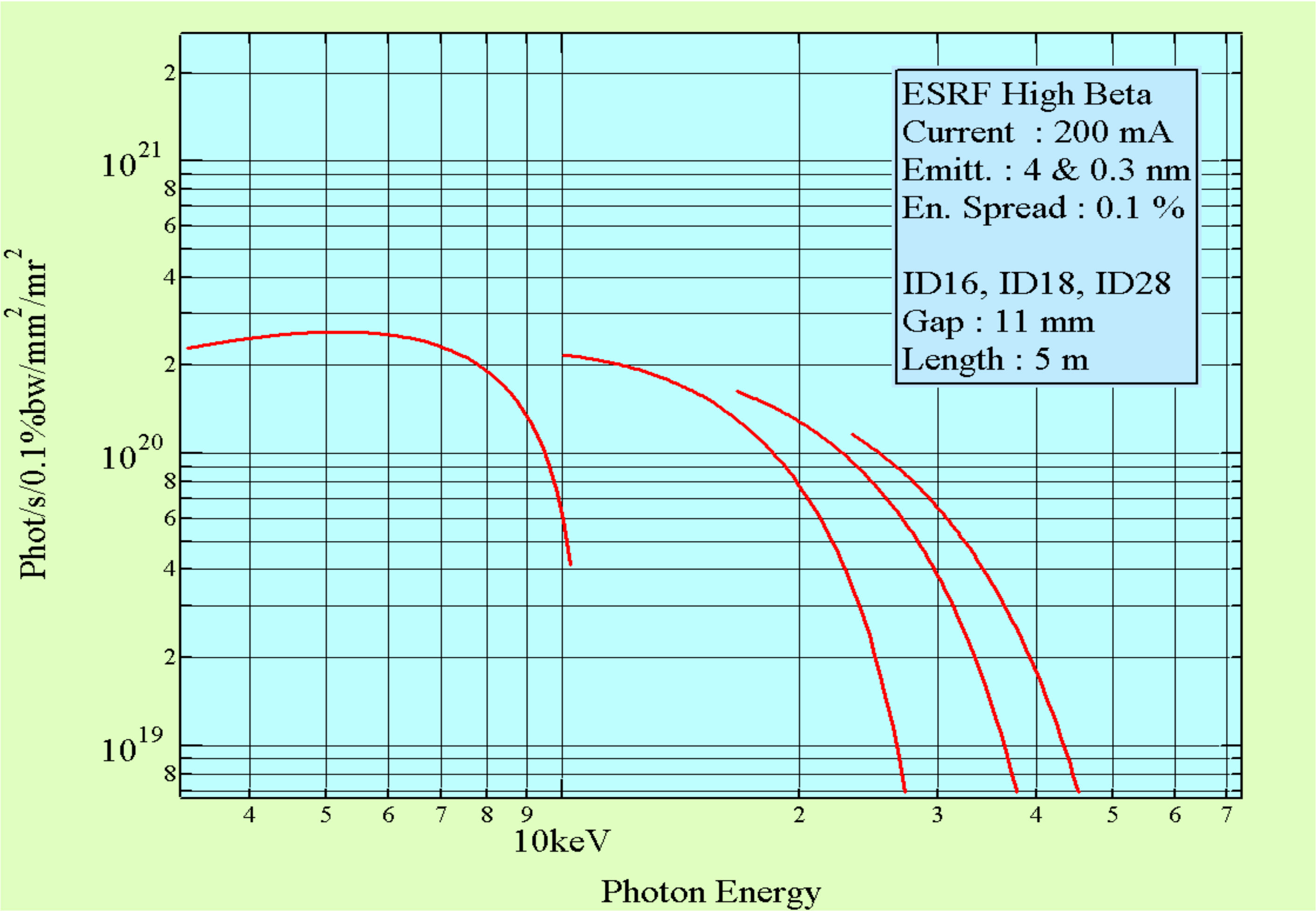
NEG Coating Facility

Chamber cross-section



Twisted wire made of:
Titanium, Zirconium and Vanadium

Brilliance in 2003



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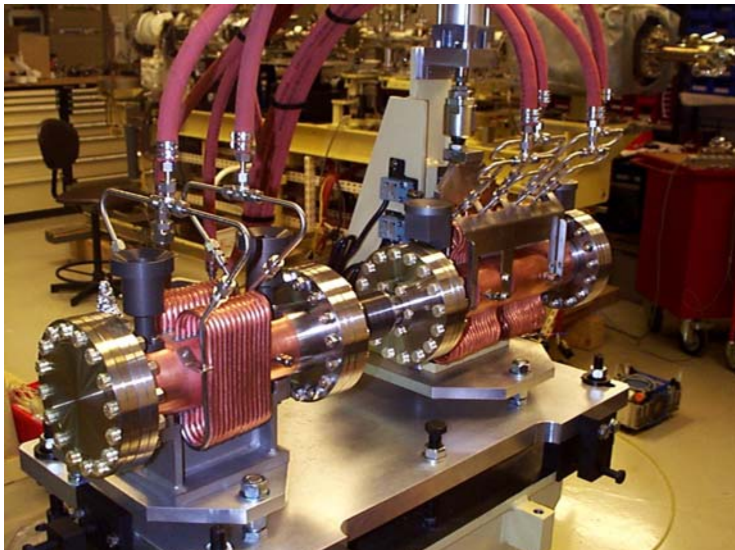
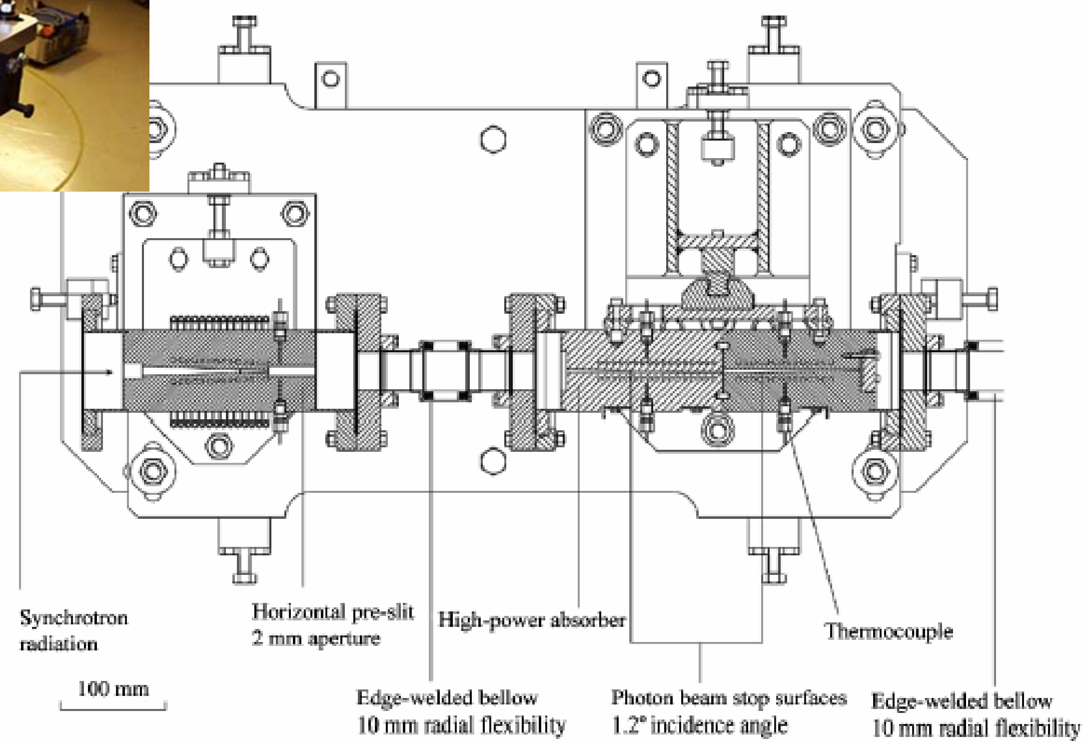
Beamline Front-End Upgrade

ESRF

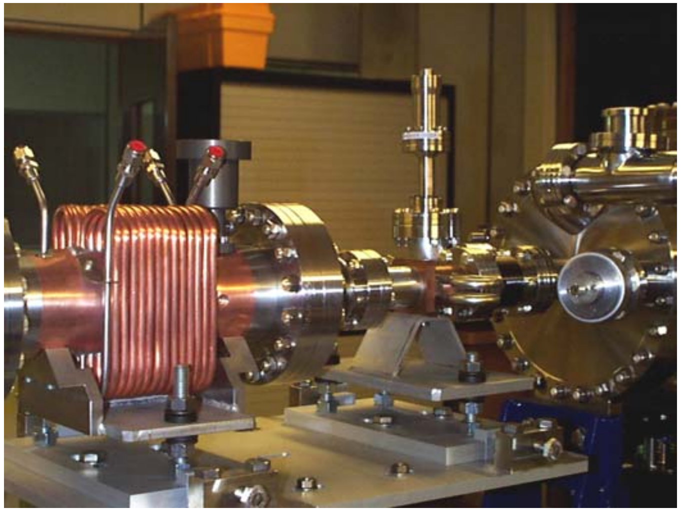
- High brilliance of tunable undulator radiation => High power density.
- A new design of beamline front-end has been produced, optimized for undulator radiation:
  - Power : 20 kW
  - Power Density : 400 kW/mr2, equiv. 2kW/mm^2 at normal incidence
- Can accommodate an undulator such that :
  - L = 5 m @ gap=11 mm and Current = 300 mA current
  - L = 4 m @ gap=5.5 mm and Current = 200 mA current
- Gradually replacing existing front-ends. Presently in operation on 13 beamlines.

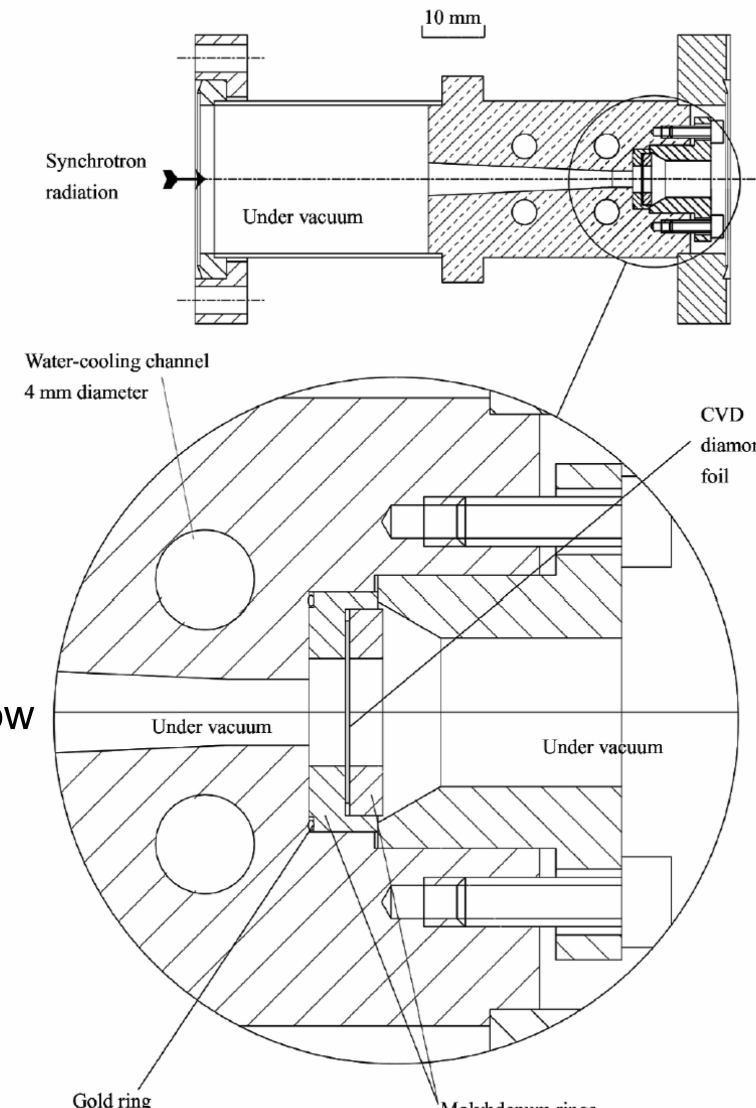
High Power Front-End Shutter





Vacuum Insulation of High Power Front-End

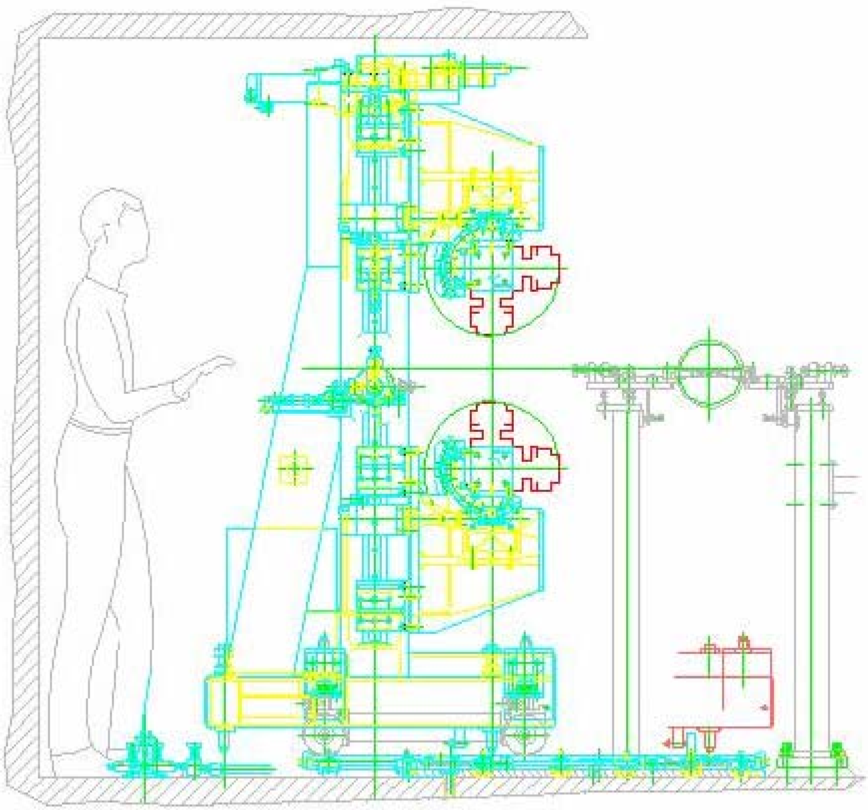


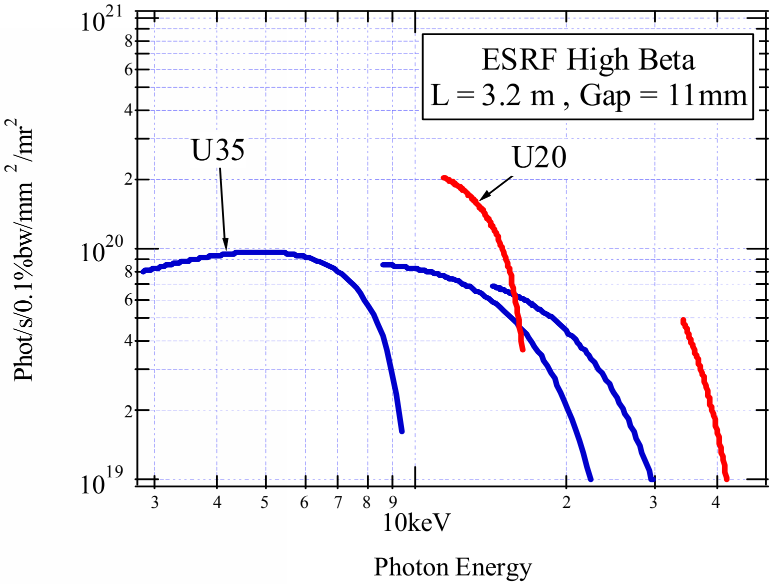


A single 0.3 mm CVD diamond window replaces the 2 x 1 mm Graphite + 0.5 mm Beryllium window

- Leak tight
- Handle higher power density
- More transparent to X-ray
- Preserves spatial coherence

Revolver Undulators



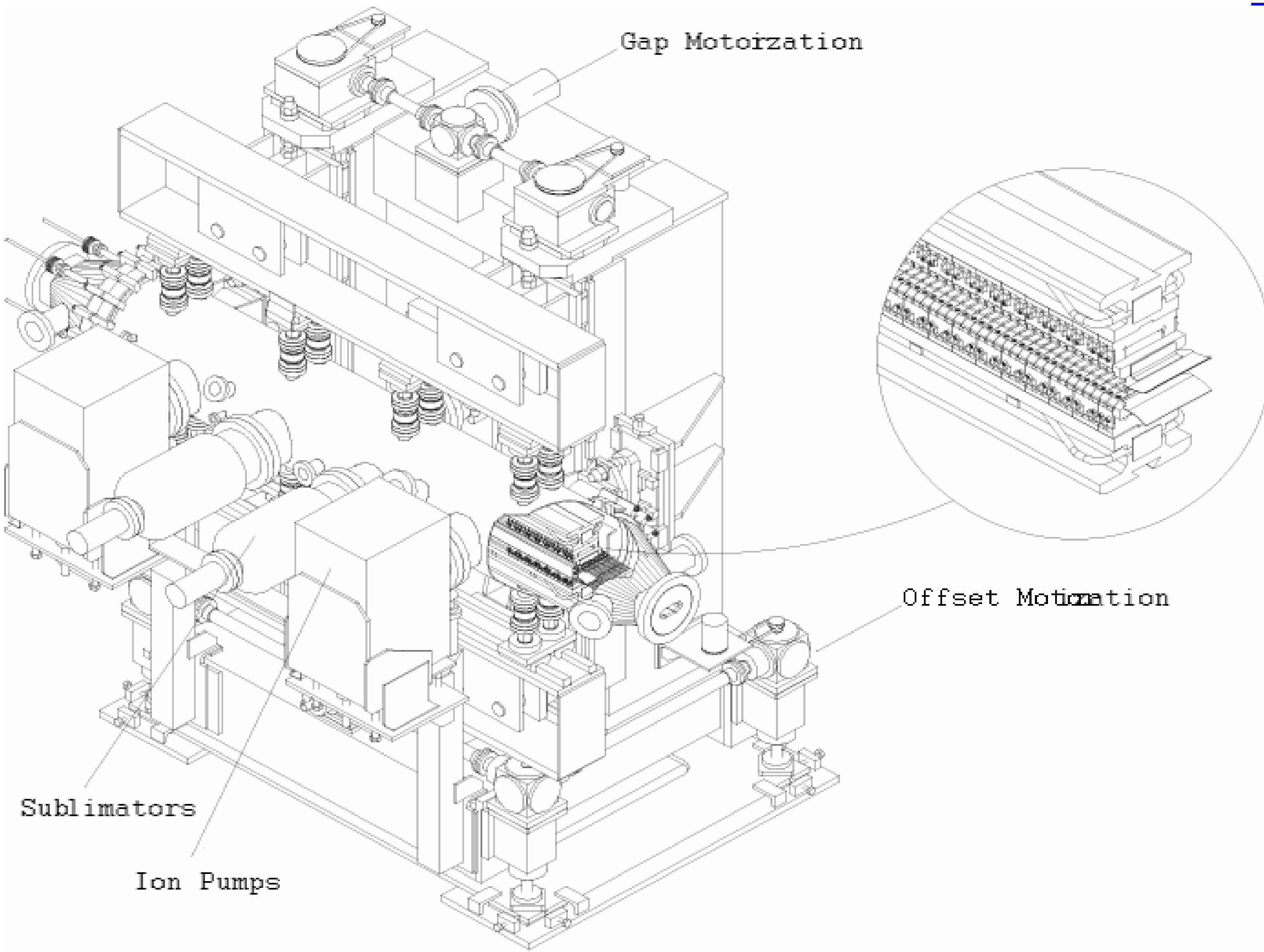


Typical Revolver Undulator :

- K=2.2, continuously tunable
  period ~ 32 mm @ 11 mm

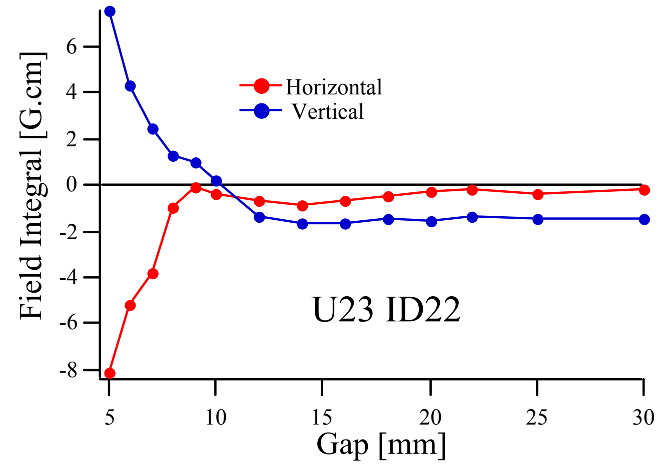
- K=1-1.5 high brilliance but limited tunability :
  period ~ 25-20 mm @ 11 mm

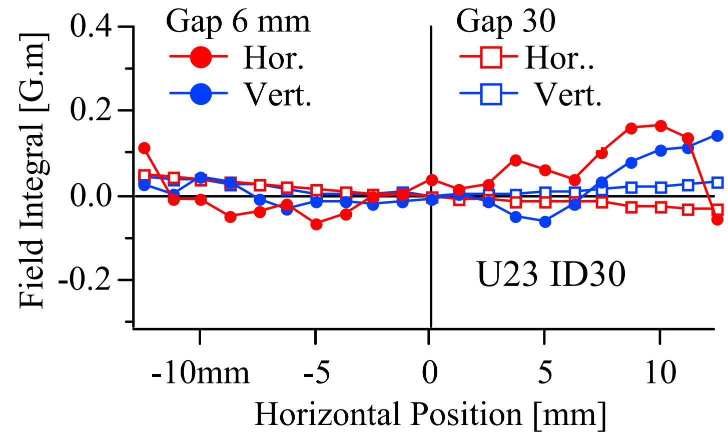
In-vacuum Undulators



Magnetic Field Measurements

On-axis field int. vs gap

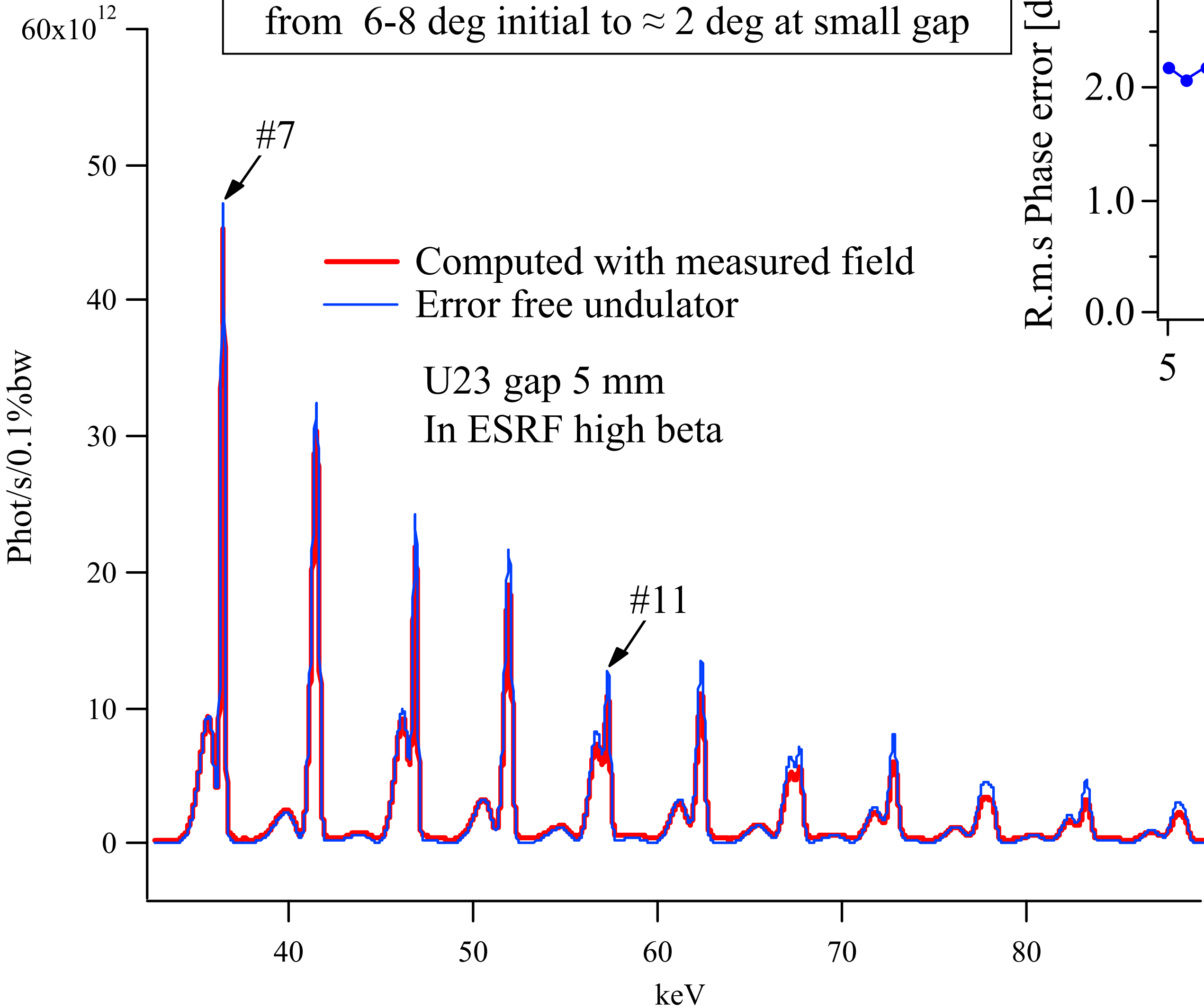


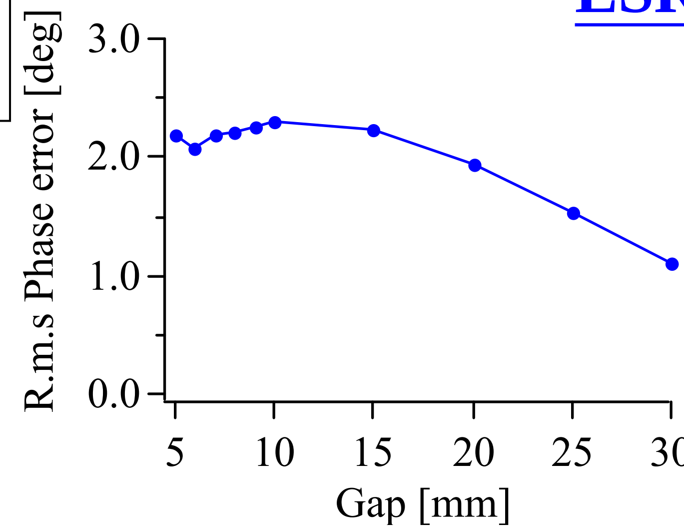


- Integrated multipoles are corrected by standard techniques.
- Low residual field integrals vs. gap confirmed by measurement on the ring. No abnormal tune shift from field errors.

Phase Shimming

Reduce r.m.s. value of optical phase error computed at each pole:
from 6-8 deg initial to ≈ 2 deg at small gap





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Status of In-vacuum Undulators

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SS	Period [mm]	L [m]	Type	Min. Gap [mm]	Rms Phase Error [deg] @ 6 mm	Field Int. vs Gap [Gcm]	Status
ID11	23	1.6	Hybrid	5	?	70	Jan 99
ID22	23	2	PPM	6	1.9	26	July 01
ID9	17	2	PPM	6	< 5	<15	July 01
ID29	21	2	PPM	6	2.3	<15	Dec 02
ID13	18	2	PPM	6	<5	<15	July 02
ID11	22	2	Hybrid	6	< 2	<15	Dec 2003
ID30	23	2	PPM	6	2.1	<15	Dec 2003
ID30	23	2	PPM	6	< 2	<15	Dec 2003

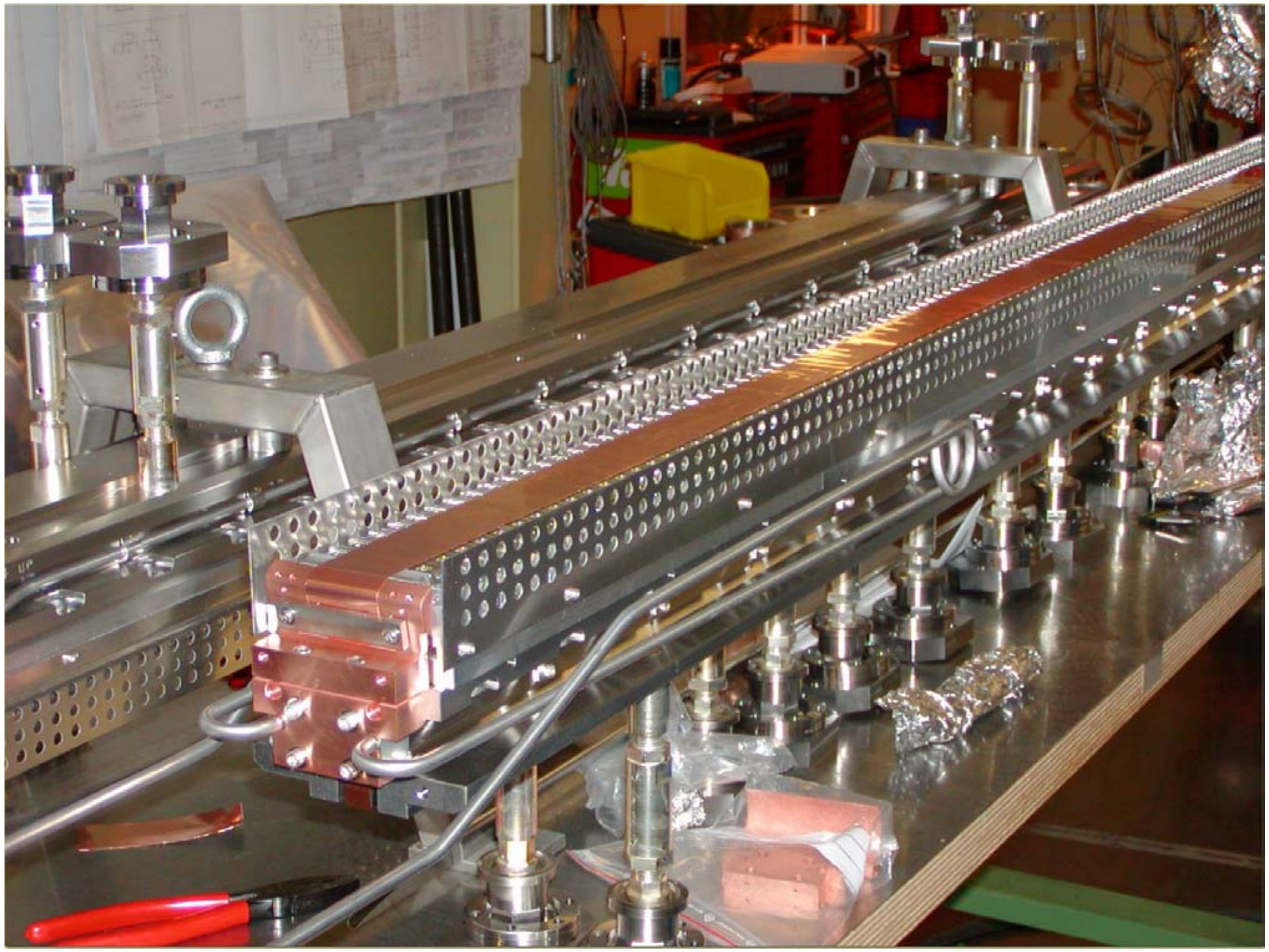
Magnet Material : Sm_2Co_{17}

- Baked at 120°C for 2 days
- No demagnetization so far (ID11 ~ 4 years @ 5 < g < 7 mm)

Copper-Nickel Sheet

Copper :
Conduct the return current and avoid resistive wall instability

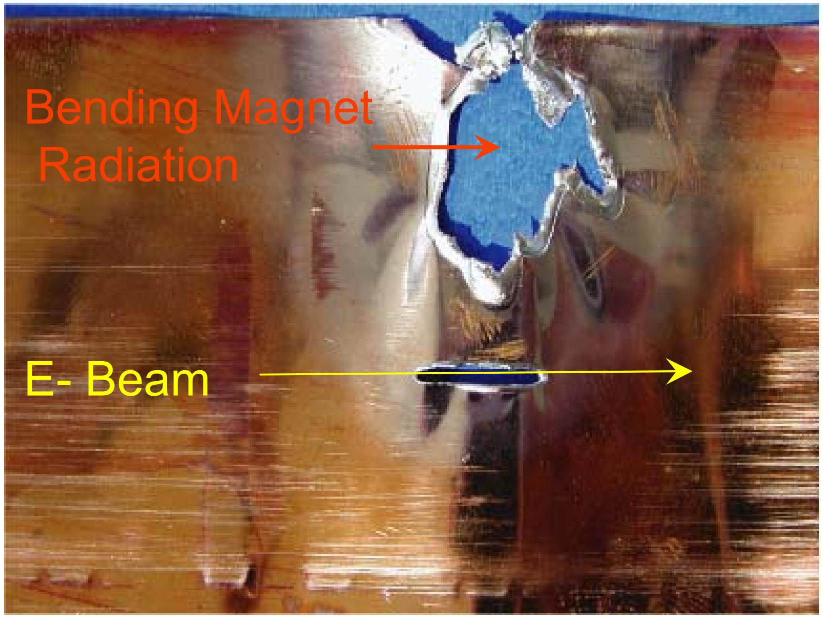
Nickel :
To ensure flatness through the sticking to the magnet and pole under magnetic force

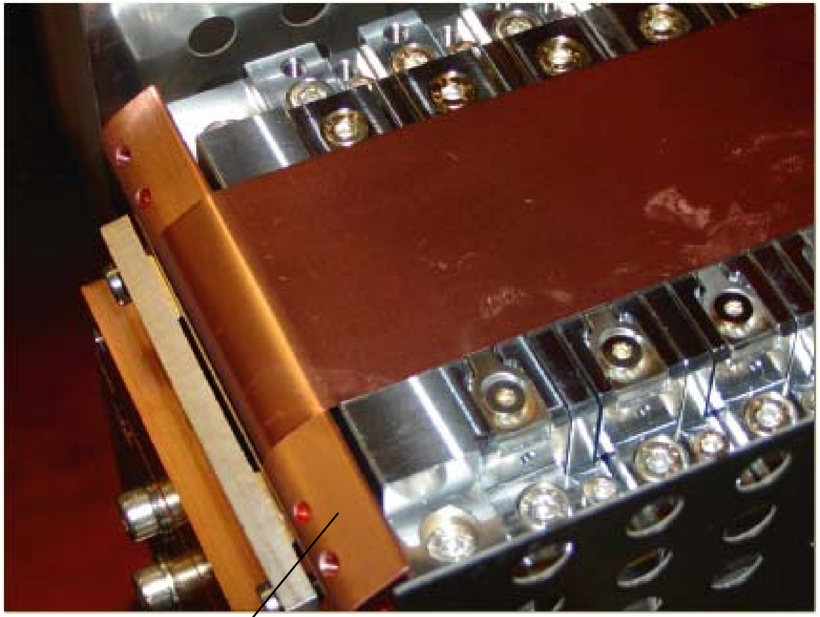


Damaged Cu-Ni sheet & Remedy

Ext.

Int.





Improve
longitudinal stretching

Cu/Ni thickness increased :
60/25 -> 60/50 micr.

No problem since then

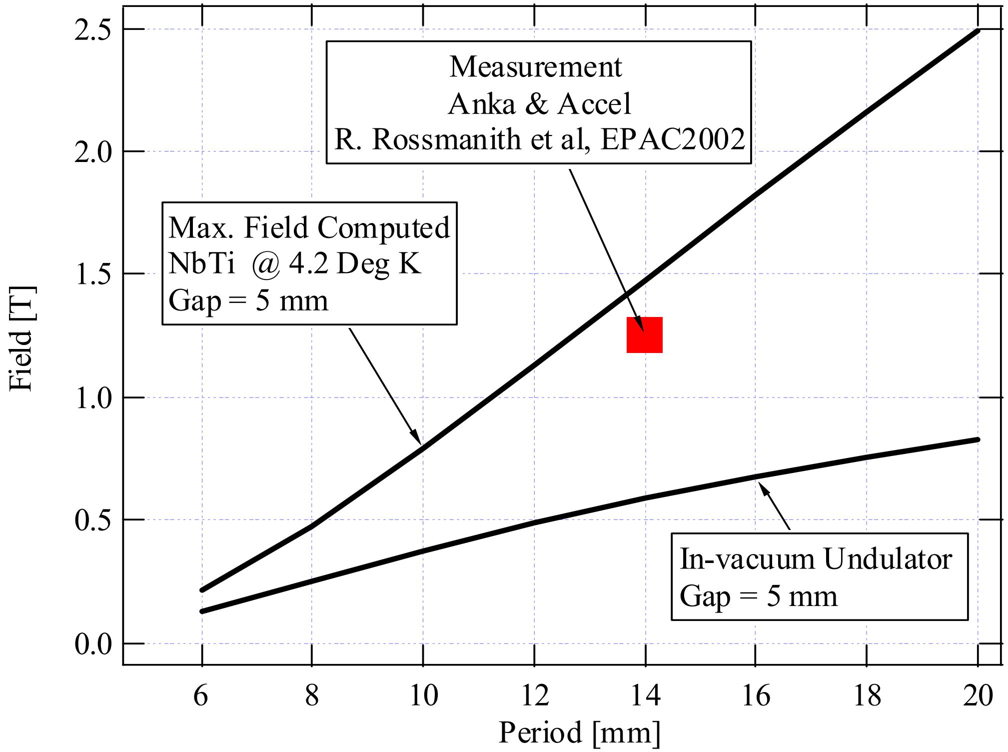
Effect on the beam for ID9, ID13, ID22, ID29

- Field integrals < 20 Gcm for all gap settings (except ID11) => No correction coils.

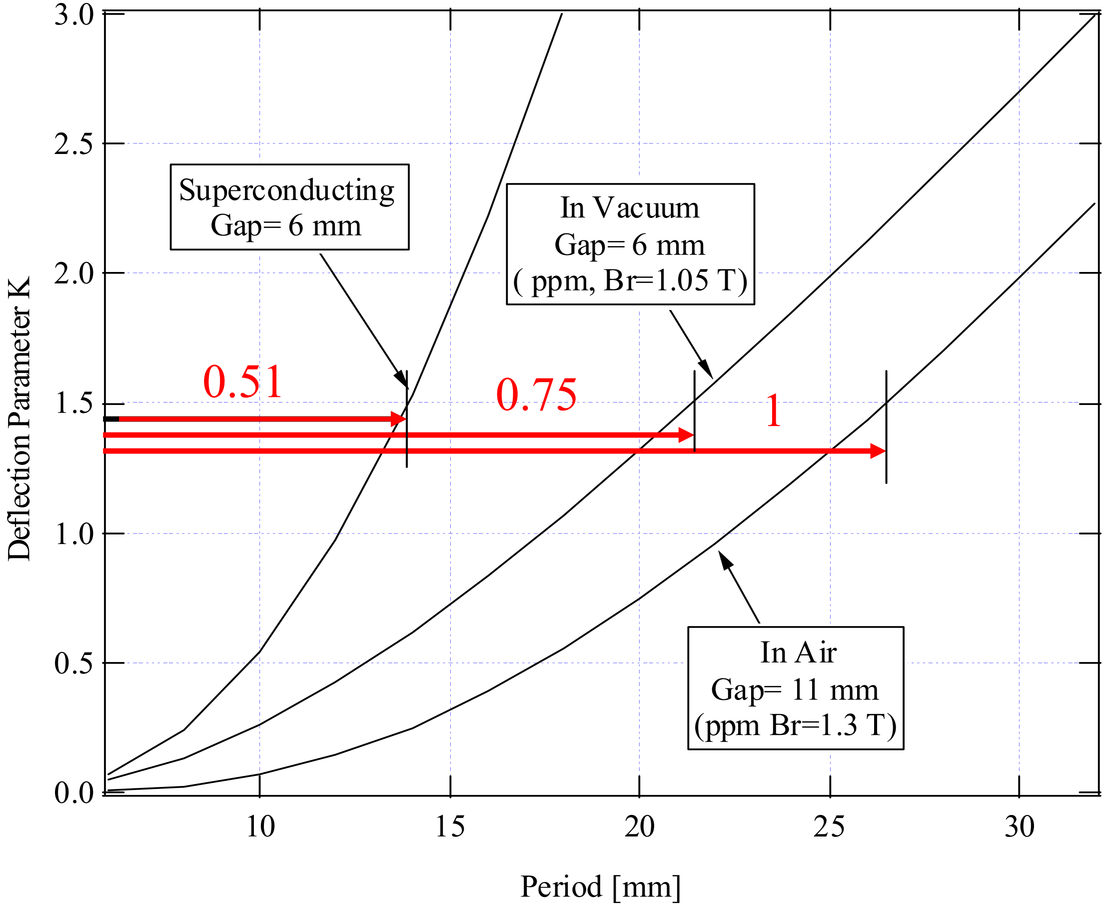
- No measurable perturbation in multi-bunch, 16 bunch, hybrid user operation (lifetime, orbit,..)

- Some small impedance or tune shift effects observed with all in-vacuum undulators closed in single bunch (preliminary).

Recent Achievement of Superconducting Undulators



Why Superconducting Undulators?



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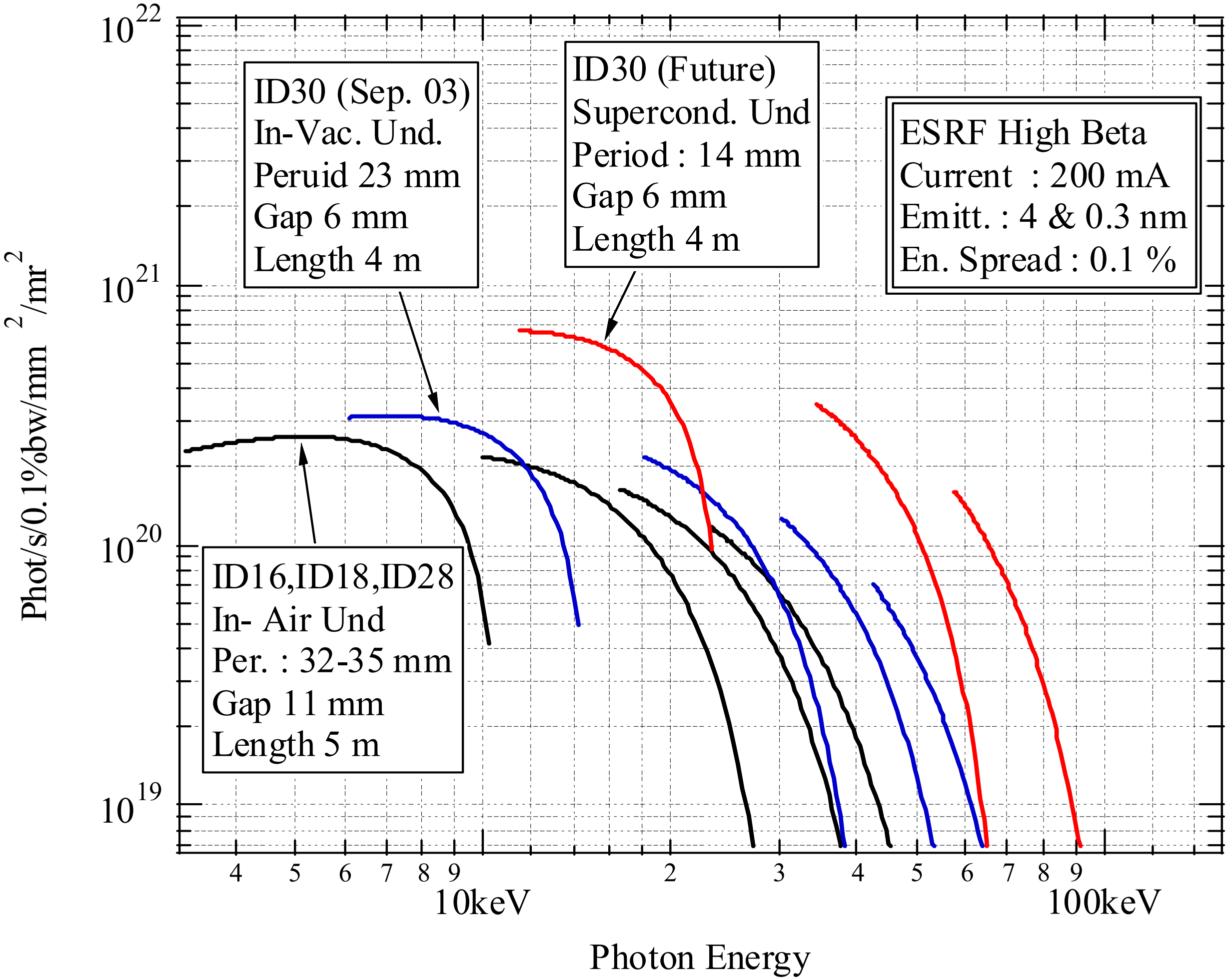
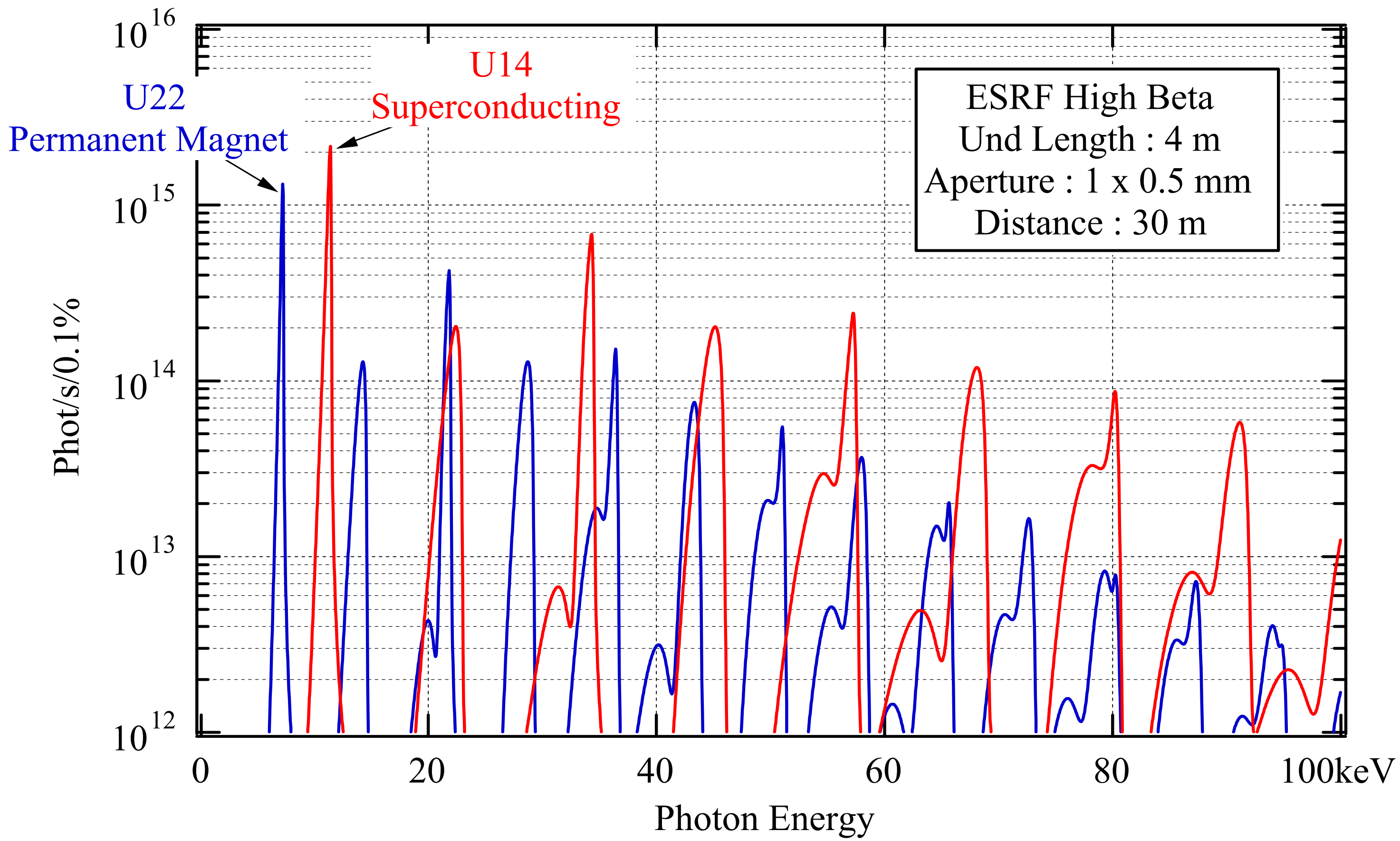
Impact on Brilliance



Flux through a pinhole



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Workshop on Superconducting Insertion Devices

ESRF, 30th June - 1st July, 2003

Review the recent development in superconducting technology :

- Wigglers & Undulators
- Engineering
  - Magnetic
  - Mechanical
  - Cryogenic
- Magnetic Field Measurement
- Beam Dynamics Issues